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FIVE-INCH HARP SYSTEM - INITIAL TEST SERIES - FORT GREELEY, ALASKA

by

Eugene D. Boyer
L. Edwin Williamson

May 1967

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A B E R D E E N   P R O V I N G   G R O U N D,   M A R Y L A N D

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EDBoyer/EDWilliamson/cr
Aberdeen Proving Ground, Md.
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FIVE-INCH HARP SYSTEM - INITIAL TEST SERIES FORT GREELEY, ALASKA

ABSTRACT

The use of a 5-inch HARP system for meteorological soundings under arctic conditions has been proposed. Feasibility tests for soundings to 200,000 feet (the present M33 radar limit) with present compatible payloads are discussed.

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INTRODUCTION

The U.S. Army Electronics Command, Atmospheric Sciences Laboratory (ECOM-ASL), White Sands Missile Range (WSMR), New Mexico, operates a meteorological rocket station at Fort Greeley, Alaska. This station, 110 miles southeast of Fairbanks ($64^{0}00'$ N; $145^{0}44'$ W), has a mission to obtain routine high altitude wind samplings; this task is hampered by the launch restrictions on the available rocket vehicles. Range safety dictates that pre-launch conditions must be monitored to 90,000 feet and the prevailing wind conditions are such that about one-third of the planned firings may be cancelled during certain periods because the safety requirements can not be met.

The gun probe systems[1*] are not in the developed state of the current meteorological rocket systems (particularly with regard to available payloads[2]), but they do have a demonstrated capacity to operate safely without major wind condition constraints.[3**] The Ballistic Research Laboratories (BRL) has conducted development tests of the 5-inch HARP system at Aberdeen Proving Ground (APG) and at the NASA's Wallops Island[5] facilities. An installation at Barbados, West Indies[6] is also being used to obtain wind data in cooperation with McGill University*** of Montreal, Canada; ECOM-ASL is conducting similar tests at WSMR.[7] During the fall of 1965, ASL suggested that one of the spare 5-inch guns at BRL be moved to Fort Greeley to conduct feasibility tests under arctic conditions. It was proposed that a 24-shot test be undertaken in the

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Superscript numbers denote references which may be found on page [illegible].

***The only gun-probe firings that have been cancelled because of winds were occasioned by the inability of the supporting radar to operate under the prevailing conditions.*

****An additional site has been put into operation (March 1967) at McGill's Highwater, Canada laboratory. This site is operating within a total impact area two miles wide by five miles long and is located two miles north of North Troy, Vermont ($73^{0}31'$ W; $45^{0}2'$ N).*

1965-66 winter period under ASL auspices and support. Because of scheduling problems and preparation time required, the test was planned for the later part of the season; in the end, unexpected compromises in the fuze and charge components had to be made to avoid delaying the test into the 1966-67 winter period.

This report discusses the preparatory tests and the firings conducted at the U.S. Army Test Center, Artillery Communications Division, Fort Greeley, Alaska, during the period 14 February to 3 March 1966.

PRELIMINARY PREPARATIONS

Operations under arctic conditions pose problems and require preparations not entailed under other conditions. The 5-inch HARP system had been operated under a range of conditions ranging from midwinter on the eastern seaboard to near tropical climate, with no particular problems.

The gun system is constructed from standard Army hardware. A 10-foot extension has been added to a 120mm T123 tank gun and a three-rod truss system is used for support. The rifling was removed to provide a smoothbored tube. The tube was mounted on a 155mm M2A1 towed field carriage. This carriage allows elevations up to 67 degrees and since it is desirable to fire at near vertical elevations, the entire system was placed on an inclined ramp (Figure 1). The flight vehicle was a centrally saboted, finned stabilized projectile (Figures 2 and 3) and the propulsion system consisted of a blend of standard Army propellants. The basic gun and mount had been qualified for arctic use and for which winterization procedures and operational techniques had been devised. These components, and some of the accessory equipment, could be considered *a priori* qualified. It was, in fact, not envisioned that the system would be required to operate in a full cold condition, but it was

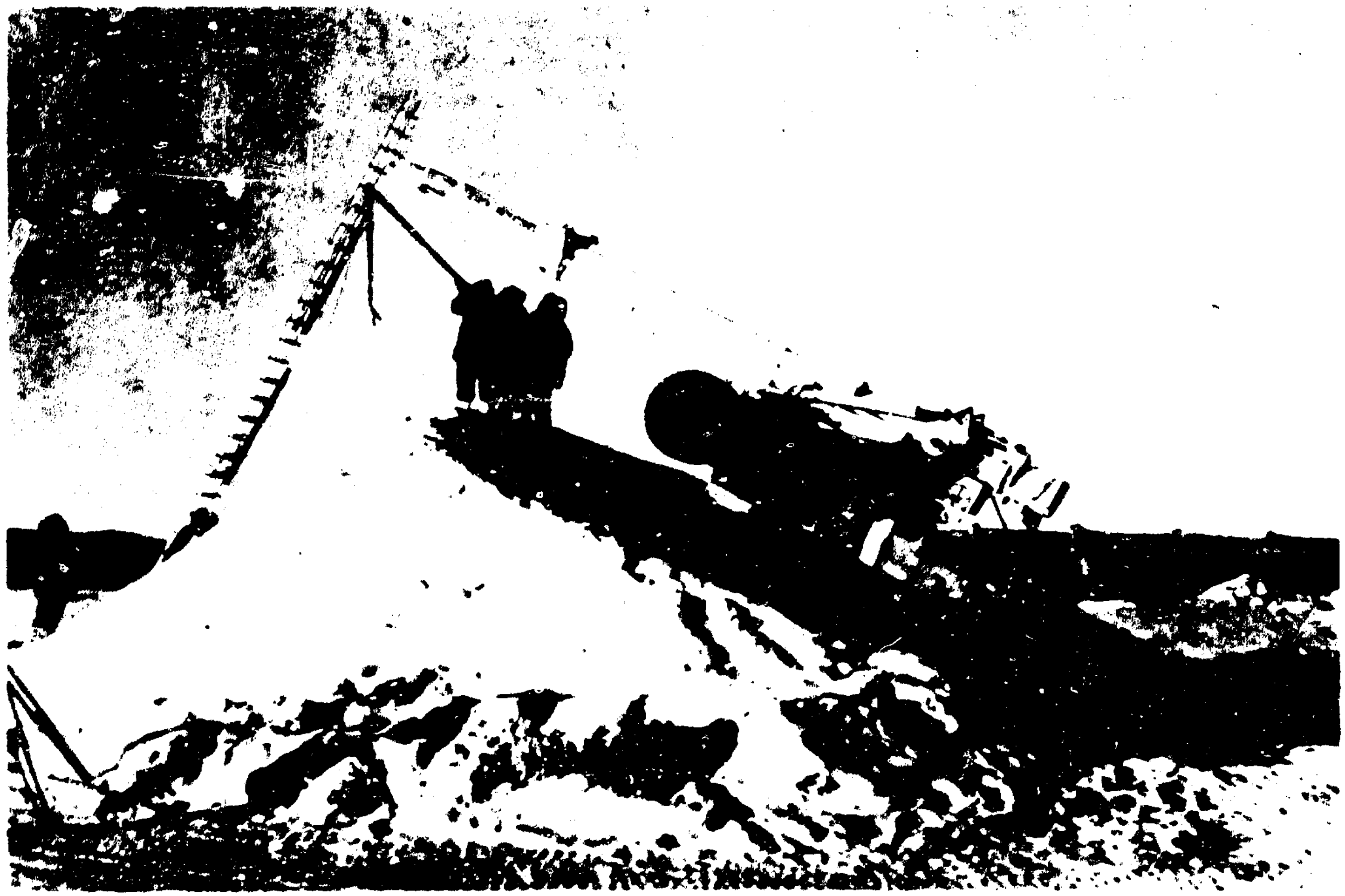

Figure 1. Five-inch gun

Figure [illegible]. Five-inch projectile

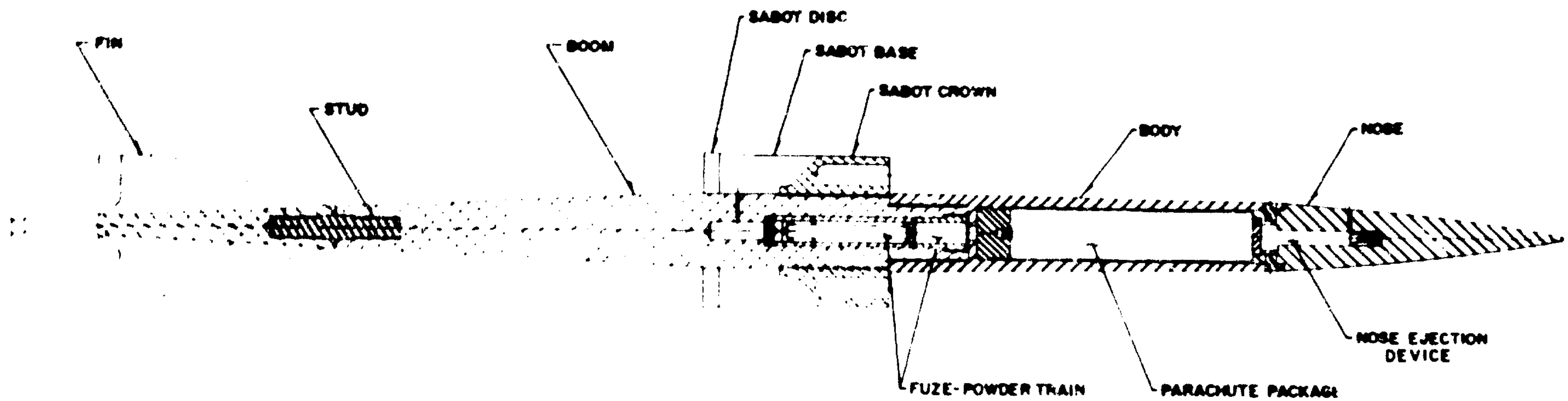

Figure 3. HARP 5-1 probe projectile

believed that safety and operational convenience* would be promoted if the components could withstand severe conditions. In any case, any limitations should be determined.

The charge most often used with the 5-inch system is a tri-granular mix (MP-0.052 inch, 0.079 inch and 0.114 inch web) of M17 propellant. The M17 composition was being replaced, in part due to poor low temperature performance, by M30 propellant; therefore, it seemed desirable to use an M30 charge for the Alaska tests. The change over was not complete and the closest charge simulation that could be made from available propellant was a bi-granular mix (MP-0.052 inch and 0.073 inch web) in M30 composition. Computations indicated that this compounding was not as good as the original charge (in that higher pressures were required to produce the same velocity), but it appeared adequate since it was not contemplated that maximum performance would be attempted in the Alaska series of firings. We investigated the new charge, by firing ten proof rounds at APG. The pressure-travel curves (Figure 4) were not as smooth during the pressure rise as those of the original charge. Various attempts were made to make minor changes in the ignition system and in the percentage ratios of the web sizes without major improvement. The available preparation time was very short so the decision was made to use the M30 charge in the present state rather than risk the possible misbehavior of the M17 charge. In the APG tests, the M30 charge was delivering a muzzle velocity of 5000 fps at a breech pressure of 53,000 psi. We decided that no attempt would be made to use a cold charge in the test series.

The gun and mount were dismantled, cleaned, and winterized for temperatures to minus 70°F, then re-assembled; likewise, the hydraulic systems and generator were prepared for arctic testing. All equipment

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**For example, operationally it is possible to leave the projectile in the gun for a long hold--for several reasons; however, the propellant charge would almost always be unloaded during a long hold.*

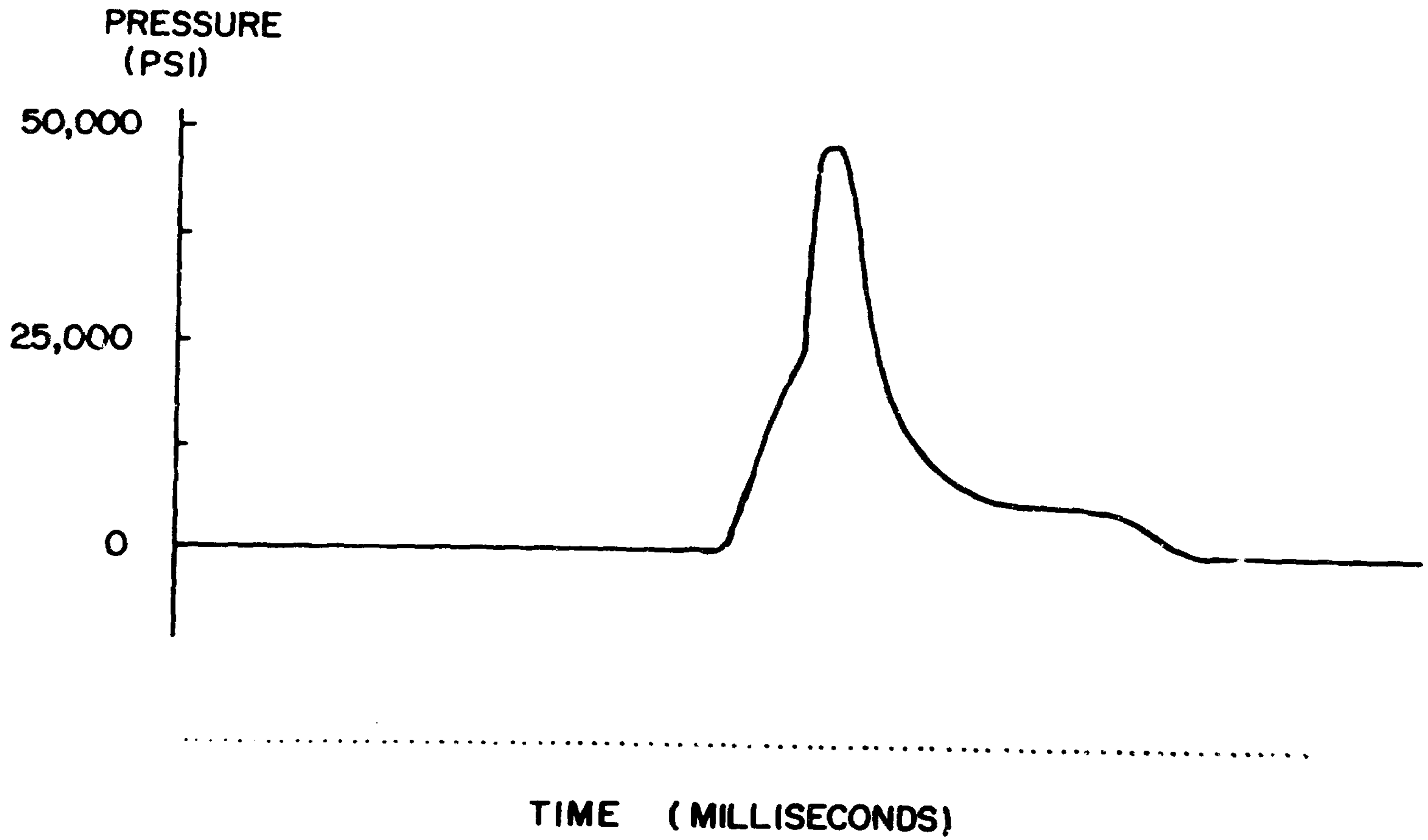

Figure 4. Pressure-travel curve

was shipped from Aberdeen on 4 January and arrived at Fort Greeley on 11 February 1966.

TEST

The gun position was prepared during the summer months. A ramp was constructed of earth, and holes were dug to accept the spades of the gun mount. This pre-construction was adequate but not compatible with the equipment available for emplacement of the gun and mount. Although a 20-ton crane with a 25-foot boom was available, this small crane was unable to raise the gun up the large hill and position it directly. A tank was used to push the gun up the hill while the crane was lifting. Due to these difficulties, the earthen hill is undesirable; therefore, a ramp as described in Reference 3 should be used.

One area of concern was the lack of instrument coverage. Instrumentation was limited to a single M33 radar and to muzzle velocity probes. Limited previous experience with M33 radars and the 16-inch gun-probe vehicles indicated that the M33 could occasionally "see" the vehicle and might lock on near extreme ranges. This suggested that a vehicle track of the 5-inch projectile was out of the question. Most of the previously used, gun-probe, radar-reflection payloads utilized the MPS-19 "S" band and the FPS-16 "C" band radars. The limited experience with the "X" band equipment indicated that only the "X" band chaff would provide an acceptable target; but parachutes yield a longer wind track than chaff and it would be very desirable to use an acceptable parachute. The M33 radar at Barbados Island was able to track the 6-foot-square, aluminized parachute once it had been placed on target by the MPS-19 radar.

Ruling out the possibility of tracking the vehicle to ejection, a wide angle search pattern was established in order to obtain the payload after ejection. Payload ejection times were set for 120 seconds. At 120 seconds after launch, the radar would proceed with its established

search pattern until the payload is acquired, or until it was determined that there was no payload placed in the described area (approximately 20 minutes). Two basic problems existed in the system which would decrease the reliability of placing the payload in the prescribed area:

1. The reliability of the payload ejection system is about 80 percent. This is attributed to the pyrotechnic fuze delay trains; work to increase their reliability is in progress.

2. The flight performance of the projectile is a function of the amount of bevel on the leading edge of the fins and the altitude from which the projectile is launched. Early shots would have to determine the proper fins configuration.

The data for all rounds are given in the table which follows. The first phase of the test was to demonstrate the capability of payload acquisition of the M33 radar. To achieve this, a target of 2.5 mil "X" band copper chaff was used. The first two rounds functioned satisfactorily with a chaff cloud track at an altitude of 200,000 feet at 138 and 142 seconds respectively (18 and 22 seconds after ejection).

During the flight development work on the vehicle, it was determined that the vehicle should spin. This was accomplished by designing a fin with a leading edge bevel that would spin the model aerodynamically. Flights at Wallops Island (sea level) indicated that fins with one, two, or three-degree bevels were satistactory. Flights at White Sands (4000 feet above sea level) indicated that only the 3° fins were satisfactory; while at Fort Greeley at 1500 feet above sea level it was anticipated that the 2° fin would be satisfactory. This did not prove to be the case. The first two rounds with 3° fins were fired successfully. The third and fourth rounds with 2° fins and no payload was observed. The rounds of impact indicated that these were short flights and therefore all other rounds employed the 3° fin.

Rd.	Date (1966)	Local Time	Temp. Deg. F	Payload	Launch Wt. (lbs.)	Charge (lbs.)	Pressure X 10^{-3}	Powder** Temp. Deg. F
1	Feb 18	1909	- 16	2.5 mil "X" chaff	27.3	32.0	51.1	52
2	Feb 19	0607	- 28	2.5 mil "X" chaff	27.3	32.0	41.5	72
3Δ	Feb 19	1400	- 4	2.5 mil "X" chaff	27.3	32.0	45.4	48
4Δ	Feb 19	1700	- 18	2.5 mil "X" chaff	27.3	33.0	54.0	56
5	Feb 19	1831	- 23	2.5 mil "X" chaff	27.3	33.0	53.2	60
6*a	Feb 22	1400	- 14	2.5 mil "X" chaff	27.3	33.0	50.8	68
7	Feb 23	1700	- 10	2.5 mil "X" chaff 2.5 mil "C" chaff	27.3	33.0	57.6	79
8	Feb 23	2100	- 6	2.5 mil "X" chaff	27.3	32.0	47.0	83
9*	Feb 24	0738	- 14	10 mil "X" chaff	27.3	31.5	48.8	90
10	Feb 24	1038	11	6 ft. chute	25.5	32.0	46.2	80
11	Feb 24	1355	12	7.6 ft. chute	25.5	33.0	50.3	78
12	Feb 24	1533	30	7.6 ft. chute	25.5	34.5	53.1	54
13	Feb 25	1010	20	7.6 ft. chute	25.5	33.0	54.4	67
14	Mar 2	1400	10	6 ft. chute	25.5	33.0	50.4	65
15	Mar 2	1500	10	6 ft. chute	25.5	33.0	52.4	64
16	Mar 2	1600	9	6 ft. chute	25.5	33.0	54.9	65
17	Mar 2	1700	5	6 ft. chute	25.5	33.0	52.5	66
18*	Mar 3	1103	- 8	2.5 mil "X" chaff	27.3	33.0	53.0	73
19	Mar 3	1201	- 5	10 mil "X" chaff	27.3	33.0	54.5	76
20	Mar 3	1300	0	10 mil "X" chaff	27.3	33.0	53.1	77
21	Mar 3	1400	0	10 mil "X" chaff	27.3	33.0	50.8	74
22	Mar 3	1433	0	10 mil "X" chaff	27.3	33.0	51.6	74
23	Mar 3	1530	0	10 mil "X" chaff	27.3	33.0	52.1	71
24	Mar 3	1630	- 2	10 mil "X" chaff	27.3	33.0	55.5	69

Launch azimuth 4630 mils, elevation 87 degrees.

a : Fort Greeley modified fin.

Δ : All rounds used 3° beveled fins except these two. These had a bevel angle of 2°.

* : Cold rounds.

** : Taken at T - 25 minutes.

Normal flight time for model with payload ejection is 290 seconds. Flight time without payload ejection is 260 seconds.

Rd.	Alt.* K/ft	Time* (sec.)	Az Deg.	Sound Impact (sec.)	Comments
1	200	142	4660	300	Good flight and payload
2	200	138	4650	280	Good flight and payload
3				215	Low flight
4				160	Low flight
5	200	153	4675	300	Good flight and payload
6				210	Low flight
7	165	317	3745	---	Good flight and payload
8	200	160	4640	271	Good flight and payload
9				145	Low flight
10	140	360	4590	269	Good flight and payload
11	130	334	4670	273	Good flight and payload
12				288	Good flight
13	138	358	4570	296	Good flight and payload
14	136	202	4350	275	Good flight -- chute did not open immediately
15	138	372	4490	310	Good flight and payload
16	146	294	4420	271	Good flight and payload
17					No information
18	200	150	4830	276	Good flight and payload
19				283	Good flight
20	138	165	4510	254	Low flight
21				120	Low flight
22	107	130	4620	210	Low flight
23	129	150	4500	237	Low flight
24				284	Good flight

*Altitudes and times are for the radar acquisition of the payload.

A total of 24 rounds were fired on an azimuth of 4630 mils and at an elevation of 87 degrees. No radar contact was made for nine of the rounds. This may be due to the improper ejection fuze system or to an unstable flight. There were 15 good flights (altitudes of 200,000 feet or better) and 8 low flights. There is no information available for one of the flights. Figure 5 plots the payload acquisition altitude as a function of time after gun launch. Two basic types of payloads were used.

1. Copper chaff
   a. 2.5-mil X-band
   b. 10-mil X-band
   c. 2.5-mil C-band
2. Metalized parachutes
   a. 100 percent radar reflective, 6-foot square
   b. 50 percent radar reflective, 7.6-foot diameter

The 2.5 mil X-band provided the best target and was acquired at 200,000 feet in five of the shots. This chaff is very light and disper[illegible] rapidly; it gave a poor wind track. The 10-mil X-band chaff was never acquired above 138,000 feet. One shot (Round 7) was tried with a mixture of 2.5 mil C-band, X-band chaff to determine if the M33 could see and track the C-band chaff. The X-band chaff was included to verify the expulsion of the payload in the event that the C-band chaff could not be seen. The radar was confused and obtained very questionable data. The cloud dispersed rapidly both horizontally and vertically.

The attempts to acquire a parachute at 200,000 feet were somewhat futile. The best acquisition was at 146,000 feet. Later, it was determined that this is probably the best that the M33 can do with these small parachutes. A new corner reflector is being tested, which gives three times more radar return signal than the parachutes; and it is anticipated that this reflector should provide an acceptable target at 200,000 feet.

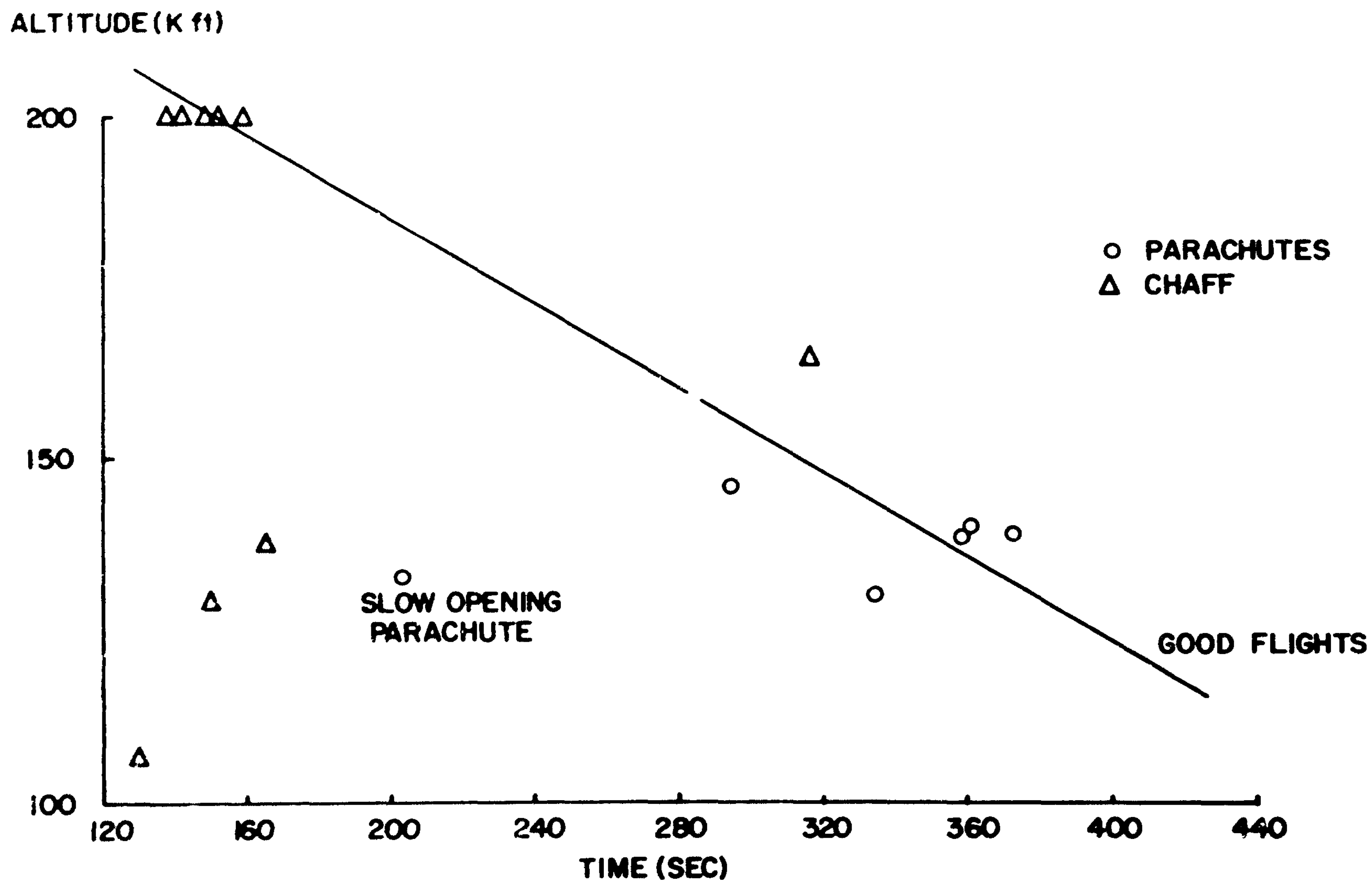

Figure 5. Payload acquisition vs. time after launch

The firings were conducted in temperature ranges from +30 to $-28^{\circ}F$. The gun propellant was kept at warm temperatures ranging from 48 to $90^{\circ}F$ (measured at T minus 25 minutes). All except three models were kept at room temperature up to T minus 25 minutes. Three models were allowed to soak in the atmospheric temperatures for a period of 12 hours before firing. Only one of these models flew, and this sample is too small to say whether there is an effect. This question will be pursued as the project moves into operational phases.

CONCLUSIONS

Although the information gathered is not complete, there is enough information to indicate the feasibility of the system for soundings to 200,000 feet. This is the restricted altitude level at the present time due to the available payloads compatible with the M33 radar. If the system is to be used in cold temperatures, the M30 propellant and vehicles should be kept at room temperatures until firing time. Attempts will be made to remove these restrictions.

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13. ABSTRACT

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